

# Nelson Biology VCE Units 1 & 2

## Answers to Chapter Questions

### Chapter 5

#### Review questions

- 1 The four basic tissues in complex animals are:
- epithelial – the covering that protects organs, lines body cavities and covers the body surface
  - connective – provides support for the organs and systems and holds the body together; examples are blood, bone, fat and cartilage
  - muscle – contains muscle cells that contract to produce movement
  - nervous – provides communication between all body parts.
- 2 The placement of eyes and the type of teeth an animal possesses help it locate its food. For example, a carnivorous animal needs to chase down its food, so its eyes need to be placed so that the animal is able to judge the distance and speed of its potential meal. The various teeth types allow it to access the nutrients inside its meal. When it catches its meal it requires gripping teeth (incisors) and then chewing teeth (molars) in order to break apart the food and allow the chemicals of its digestive system to digest and absorb the available nutrients.
- 3 The main functions of the digestive system are to ingest, digest, absorb nutrients and eliminate wastes via egestion. The digestion of macromolecules so that they can be absorbed into the internal environment of the animal occurs like this:
- Carbohydrates are digested to produce glucose – monosaccharides.
  - Proteins are digested to produce amino acids.
  - Lipids are digested to produce fatty acids and triglycerides.
- 4 The structures through which food must pass are, in order, the mouth, teeth and tongue; epiglottis and oesophagus; stomach; small intestine (duodenum, jejunum and ileum); and the large intestine (colon and rectum).

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Enzyme	Function
Amylase	Digestion of starch to produce glucose
Pepsin	Digestion of protein to produce peptides
Trypsin	Breaks down long-chain polypeptides to shorter-chain peptides
Lipase	Digestion of fats to produce fatty acids and triglycerides

- 6 Absorbed nutrients can leave the small intestine via either the bloodstream or the lymphatic system. Fatty acids and triglycerides enter the lymphatic system via the lacteals in the villi, whereas amino acids and monosaccharides enter the bloodstream via the capillaries in the villi.

- 7 A number of structures increase the surface area of the digestive system. These include the folds in the stomach and the layers of villi in the small intestine.
- 8 Students should be able to construct this using the information in the text.
- 9 The purpose of chewing the cud is to attempt to break down the tough cellulose wall of the plant material in order to increase the surface area available for the action of enzyme-producing bacteria.
- 10 The only organisms able to digest cellulose are bacteria that are able to produce cellulase. They are usually located in the gut of herbivorous animals such as cows, sheep, kangaroos and koalas.
- 11 The structure of the cow's stomach is quite different to that of the human stomach as its function is quite different. The human stomach is the site of protein digestion. Cattle do not usually consume protein; however, their consumption of low-energy plant material is high. The cow's stomach is divided into four chambers with plant material at various stages of digestion.
- 12 The human digestive system ensures the digestion of many materials as humans are generally classified as omnivores. Other animals included in the text have a less varied diet and this is reflected in their digestive systems.
- 13 The gizzard may assist in the mechanical digestion of organic matter. The crop could act as an area of storage for undigested food.
- 14 Plasma is the pale yellow fluid portion of the blood. It is composed of whole blood without the red and white blood cells and the platelets. It also contains proteins.
- 15 The main plasma protein, albumin, helps keep the water in the capillaries by osmosis; the immunoglobulins provide antibodies against disease-causing organisms; fibrinogen is involved in forming blood clots. The plasma proteins also carry substances such as calcium, drugs, hormones, lipids, vitamins and cholesterol; they keep the acidity of the blood at an optimal level; and they provide a source of amino acids.
- 16 Haemoglobin enables blood to carry 20 mL of oxygen per 100 mL of blood, about 70 times more oxygen than it could without this red protein. It can also release oxygen easily in regions of low concentrations. Haemoglobin also carries about a quarter of the carbon dioxide in the blood.
- 17 White blood cells function collectively to fight foreign substances that enter the blood. They engulf material and destroy poisons, produce antibodies and release chemical messages and enzymes.
- 18 Platelets are smaller than red blood cells and are shaped like flattened discs. They release chemicals at the site of injury in a blood vessel, causing it to contract and reduce blood loss. They also clump together to help form a clot.
- 19 The main functions of the circulatory system are to ensure oxygen is transported to all cells in the body and that nutrients are also delivered and that wastes such as carbon dioxide are removed.

- 20** The circulatory system is the collection of arteries, veins and capillaries that ensure that blood travels to all parts of the body and the cardiovascular system. This includes the earlier-mentioned blood vessels as well as the heart, which drives the blood around the body and back again.
- 21** To determine if a blood vessel is attached to the heart the following would need to be taken into account:
- If it is attached to a ventricle and coming out of the top of the heart it would be an artery.
  - If it is attached to an atrium and leading into the side of the heart it would be a vein.
  - If it has a thick muscular wall, it is more likely to be an artery.
  - If it has a thinner, less muscular wall it is most likely to be a vein.
- 22** The heart has four chambers: there are two thin-walled atria and two more muscular ventricles. Blood enters the right atrium from the general body system of blood vessels and passes into the right ventricle. When the right ventricle contracts, it pushes the blood into the arteries that lead to the lungs. There, oxygen diffuses into the blood and carbon dioxide passes out into the air in the lungs. The now oxygen-rich or oxygenated blood passes back into the heart through the left atrium and into the left ventricle. When this ventricle contracts, the blood is forced into the aorta, the largest artery, which, through its many branches, takes blood to all parts of the body.
- 23** Use the diagram of the heart, Figure 5.20.
- 24** The blood is kept flowing in one direction in the heart by the presence of four valves, one between each atrium and ventricle (atrioventricular valves) and one between each ventricle and the artery it leads to (the pulmonary valve and the aortic valve). The two ventricles contract at the same time, and the atria contract at the same time; however, the ventricles and atria contract at different times. This leads to the two atrioventricular valves snapping shut at the same time as the ventricles contract. The pulmonary and aortic valves close when the ventricles finish contracting, so blood under pressure from the enlarged elastic arteries does not flow back into the heart. When a stethoscope is used to listen to the heart, the sound of the valves closing and the sudden stop of blood flow can be heard. (When the water is suddenly turned off in some houses, a hammering or clanging noise can occur in the pipes; this is similar to what causes the sounds in the heart.)
- 25** Arteries take blood away from the heart; veins carry blood to the heart. Capillaries are found between these two blood vessels. The walls of the arteries are thicker than those of veins. This is because arteries have a lot more muscle and elastic fibres than veins. The lumen of the vein is larger than that of the artery. Veins have valves in them to help keep the blood flowing to the heart. Unlike arteries and veins, capillaries have very thin walls and are very narrow. Their walls are only one cell thick, allowing nutrients and wastes to diffuse into and out of neighbouring cells.
- 26** Albumin keeps fluid in the circulation by its osmotic effect, especially after blood has passed through a capillary, and some plasma has been forced out by the pressure created as the vessels get narrower. Albumin molecules are too big to be forced out of the capillary walls, hence creating a high osmotic pressure inside the capillaries. This results in fluid being drawn back into the capillaries by osmosis.

- 27 Some water and protein would be left in the spaces between the cells if it were not for the lymphatic capillaries. These small blind-ended tubes allow the fluid and protein to enter through tiny flaps that act as one-way valves between the cells in their walls. The fluid in the lymph vessels flows eventually to the heart, to rejoin normal blood circulation. It is pushed along in much the same way blood in the veins is moved, by the muscle pump. Contracting muscles squeeze the lymph vessels and the valves in the walls maintain a unidirectional flow to the heart.

28 Circulatory systems of different animals

Open circulation	Closed circulation			
	One-chambered heart	Two-chambered heart	Three-chambered heart	Four-chambered heart
Arthropods	Squids	Fish	Amphibians	Birds
Most molluscs	Annelids		Most reptiles	Mammals

- 29 The processes of life require the constant supply of oxygen (for cellular respiration) and the removal of carbon dioxide, a by-product of cellular respiration.
- 30 Generally the gas exchange surface has to:
- be thin and permeable so the molecules can move across it easily and quickly
  - be moist, so that the gases can dissolve in the water and diffuse from one side to the other
  - be as large an area as needed by the organism, especially to provide oxygen for its varying energy needs
  - have a greater supply of gas on one side than the other.
- (It should also be pointed out that when gases pass through the respiratory surfaces, they do so by diffusion only; there is no active transport involved, as occurs in the case of certain nutrients being absorbed from the small intestine.)
- 31 The surfactant in mammalian lungs is a detergent-like lipoprotein that reduces the surface tension inside each alveolus. This prevents the alveolar walls from being pulled inwards so that the alveoli do not collapse and the lungs can expand. (Surfactants are also found in the other lung-breathing vertebrates.)

**32** Characteristics of efficient gas-exchange systems:

<b>Characteristic</b>	<b>Fish (gills)</b>	<b>Mammals (lungs)</b>
Moist	Live in water.	Alveoli are kept moist.
Thin	Gill plates are thin.	Distance across alveolar and capillary walls is less than 1 micrometre.
Large surface area (SA)	SA is comparatively large as there are many filaments that have many gill plates.	700 million alveoli give a SA of about a tennis court.
Greater concentration of gas on one side	The concentration of oxygen in water is higher than it is in the capillaries of the gills; that of carbon dioxide in capillaries is initially higher than it is in the water.	Air in the lungs has a higher concentration of oxygen than in the blood in the capillaries; blood has a higher concentration of carbon dioxide than do the lungs.

(One advantage of air is that at 0°C is that air is 775 times less dense than water and thus it is easier for animals to move air and to extract the oxygen, compared to moving water. Thus, fish may expend about 20% of their total oxygen consumption in the act of gas exchange, as compared to about 1–2% in mammals, including humans.)

- 33** During inhalation the muscles lift the ribs upwards and outwards at the same time as the diaphragm contracts and moves downwards. The lungs expand because the pressure around them has decreased. During exhalation the reverse happens, with the ribs coming down and in and the diaphragm moving up and forcing the air out.  
(If a person gets a hole in their chest wall through an accident or knife wound, the person may not be able to breathe even though the lungs themselves may not be damaged. This is because when the chest expands, the hole lets air in and the pressure around the lungs does not decrease, so the lungs cannot expand and take air in.)
- 34** Most of the carbon dioxide is carried as bicarbonate ions inside the red blood cells. The rest of the carbon dioxide is either dissolved in the plasma or carried in the haemoglobin molecules.
- 35** The rate of breathing is controlled by the level of carbon dioxide in the blood. Carotid bodies, tiny organs found in the carotid arteries, detect the amount of carbon dioxide in the blood. If the level is too high, the brain sends impulses to the muscles of the ribs and diaphragm to contract and thus bring fresh air into the lungs, thereby increasing the rate at which carbon dioxide is lost in exhaled air and lowering the carbon dioxide level in the blood.
- 36** Ammonia has one nitrogen atom, urea has two nitrogen atoms and uric acid has four. Creatinine, a waste product from muscle metabolism, has three nitrogen atoms.
- 37** Refer to Figure 5.32.
- 38** The blood in the glomerulus is under a lot of pressure because the arteriole coming out is narrower than that going in, so some of the blood is pushed, or filtered, out of the capillaries into the Bowman's capsule. This contains everything that was in the blood except the blood cells and large proteins such as albumin, fibrinogen and antibodies.

- 39** Substances that are reabsorbed into the bloodstream from the tubules include salts, glucose, amino acids and water.
- 40** Substances that are secreted or released into the lumen of the tubule are ammonia, potassium and hydrogen ions, histamine, creatinine, and drugs such as aspirin and penicillin.
- 41** The kidney uses more energy proportionally than the heart because of the amount of energy it uses in active transport reabsorbing substances such as amino acids, sodium ions, phosphate ions and glucose.
- 42** The final amount of water is reabsorbed from the collecting tubule.
- 43** The kidneys assist in maintaining water balance by either increasing or decreasing the urine output. If there is excess water intake, less water is reabsorbed in the nephron, thus creating more urine. Conversely it adjusts for increased exercise or reduced water intake by lowering the urine output.
- 44** The Australian hopping mouse is able to get by without drinking water by retaining the water produced during cellular respiration. Enough water is produced to allow it to survive in arid environments.
- 45** The diet of carnivorous animals is high in protein (meat). When digestion occurs the protein is broken down to produce amino acids. If the amino acids are not utilised almost immediately, the body has no facility to store amino acids, so they are further broken down and the nitrogen is removed and excreted. The other parts of the amino acid molecule are recycled and may be stored as an energy source.
- 46**
- a** Plants are mostly composed of carbohydrate. They do not move around and they are able to make their own protein from inorganic molecules found in the soil, usually in low supply. Plants have a lower turnover of nitrogenous products than animals.
  - b** Plants do not move around and therefore the need to release energy during cellular respiration is greatly reduced.
- 47** The liver removes haemoglobin from the breakdown of old blood cells. The product from this (bilirubin) becomes part of the bile and causes the brown colour of faeces. The liver also breaks down chemicals such as alcohol, barbiturates and medicinal drugs.
- 48** Refer to Table 5.6. The removal of wastes in the various forms is related to the toxicity of each of the waste products. The toxicity is related to the amount of time taken to excrete the waste from the organism's body. Ammonia is the most toxic and must be excreted fairly quickly, and can be quickly dissipated in an aquatic environment.
- 49** Fish get rid of nitrogenous waste as ammonia because they live in an environment where water is readily available and ammonia is very soluble in water.
- 50** Uric acid is less toxic than ammonia and less soluble, so water is not required to remove it. Lizards are terrestrial animals and water is not always available; excreting any water from their bodies is wasting a valuable resource.

- 51** Each species of animal has the structures to produce only one type of nitrogenous waste product. The structures in kidneys or similar structures determine the form the waste will take.
- 52** Other methods of non-nitrogenous waste excretion include:
- the liver – broken-down blood cells, haemoglobin and some other chemicals are excreted in the bile from the liver and are eventually eliminated in the faeces
  - the lungs – carbon dioxide is removed via the lungs
  - milk – this is a potential, though minor, route of chemical excretion, but more importantly is a potential means of chemical exposure for breast-fed infants. Most chemicals enter milk by diffusion from the plasma. Because the lipid content of milk is higher than that of plasma, lipid-soluble chemicals diffuse readily into the milk and actually reach a higher concentration in the milk than in the plasma.
  - phagocytes – these cells move around the body tissues and surround foreign particles. Waste stored inside these cells is removed from contact with the organism and could be regarded as eliminated
  - skin – heat could be regarded as a waste product. It is removed from the bodies of animals that have a circulatory system, heat travels in its fluid from the deeper portions of the body to the surface. At the body surface, heat is lost by convection, radiation, conduction and evaporation of sweat.
- 53** A simple way to check one's level of hydration is to check the colour of the urine. If it is yellow-orange, then the person probably needs to drink more liquid. It is good to try to keep urine clear. A lifetime of continually expecting the kidney to remove wastes with little water may help to cause kidney stones or gout.
- 54** The final amount of water that is reabsorbed is determined mainly by the permeability of the collecting tubule. A hormone called antidiuretic hormone (ADH) affects how much water can flow through the cells lining the tubule. (Diuresis means passing a lot of urine; a diuretic drug increases the amount of water excreted. Thus antidiuretic means reducing the amount of water in the urine. This is achieved when the tubules reabsorb more water.) The ADH is released by the pituitary gland in the base of the brain. Osmoreceptors, which detect how concentrated the salts are in the blood, are near the pituitary gland. If the salt concentration is higher than normal (there is not enough water in the blood), then more ADH will be released from the pituitary into the blood. When this flows through the kidney it causes the collecting tubules to reabsorb more water, thus restoring the normal proportions of salts and water in the blood.
- 55** Alcohol reduces the amount of ADH released from the pituitary gland. Thus the kidney tubules do not reabsorb as much water as normal, and so heavy alcohol drinkers have to pass urine more often, compared to drinking the same volume of water.
- 56** The problem freshwater fish have with water balance is that they normally tend to gain water by osmosis and lose salt. They overcome this by excreting large volumes of dilute urine (about one-fifth of their weight per day), actively absorbing salts using specialised cells in their gills and rarely drinking water.  
The marine bony fish's problem is that it would normally lose water and gain salt. Constantly drinking water (and salts), excreting small amounts of urine and having gills that actively pump out ions overcome this.  
The marine cartilaginous fish such as sharks and rays have a higher urea concentration in their blood, which equals the osmotic effect of sea water, so there is little osmotic loss of water compared with bony marine fish.

- 57** Marine birds and lizards have glands that release a concentrated sodium chloride solution. In birds, the glands open into their nose where the salty solution drips or is sneezed out. In turtles, the glands are located behind the eyes and the salty fluid appears, making the animal appear to shed tears.
- 58** Insects and spiders have Malpighian tubules to help control their waste and water balance. These tubes are closed at one end in the general body cavity and are surrounded by blood. Potassium ions are pumped into the tubule; water and other solutes follow osmotically. As this solution flows along the tubule, water is reabsorbed and uric acid is produced. The uric acid flows into the hind gut from the Malpighian tubule.

### **Apply understandings**

- 1** The fish will be mechanically digested in the mouth by the teeth with the addition of saliva. As it moves down the oesophagus into the stomach the protein will be digested by the enzymes pepsin and trypsin in the highly acidic environment. The rest of the food will be churned until it is of a thick soupy consistency, called chyme. As it passes out of the stomach the acid will be neutralised by the bicarbonate juices released by the pancreas into the top part of the small intestine. As the chyme moves down the duodenum bile, produced by the liver and stored in the gall bladder, will enter the tract and work as a detergent on the fat globules, mechanically digesting the fat. Then lipases and proteases will enter from the pancreas and complete the digestion of the meal prior to absorption by the villi.
- 2** When a person is suffering diarrhoea, the matter in the large intestine moves through quickly; thus water is not able to be absorbed and the waste that is then eliminated is quite runny. In constipation, waste moves slowly through the large intestine, all available water is absorbed, producing a hard dry faecal body that is difficult to expel. In an ideal situation at least 50 mL of water needs to be absorbed into the body via the large intestine. In this manner enough fluid remains in the waste material to allow easier passage out of the body and not enough to produce a runny discharge.
- 3** The food cows ingest (grass) requires a great deal of mechanical digestion. In this way a greater surface area is exposed to the action of enzymes produced by the bacteria that populate parts of their digestive tract. As grass is very low in energy, the more that is able to be ground up ready for the action of enzymes, the better for the animal. The grinding molars allow maximum mechanical digestion of the grass material.
- 4** Arteries are required to carry oxygenated blood to all parts of the body. It needs to reach its location very quickly and this is assisted by the pumping of the heart. The arteries therefore need to be clear of obstructions so that the oxygenated blood can reach the cells that require the oxygen. Any blockage slows down the movement of the blood and can lead to the death of cells if they do not receive the oxygen they need.
- 5** Placing a person in a thermal blanket after severe blood loss ensures that the warm fluid lost does not have a negative impact on the person's body temperature. The fluid lost must be restored, hence the intravenous drip. This fluid, however, may not be at the right temperature and the body must expend energy to maintain the body temperature.



- 6 A ventricular septum defect (VSD) would allow the mixing of oxygenated and deoxygenated blood and the circulation of oxygen-rich blood. This could lead to low oxygen supply in vital organs and muscles. The pressure generated by the simultaneous contraction of the ventricles would also reduce the pressure in the movement of blood out of the ventricle into the aorta. ASD would most likely be an atrial septum defect where blood would mix in the atrial chambers.
- 7 See the answer to Review Question 32.
- 8 It is along the loop of Henle that water is reabsorbed into the bloodstream. The longer the loop, the more water has an opportunity of being reabsorbed.
- 9 Drink would increase to 2800 mL, urine would increase to 2900 mL (and be more dilute), both totals would increase to 3900 mL. All other figures would remain the same. If a person halved their water intake, drink would decrease to 700 mL, urine would decrease to 800 mL (and be darker) and both totals would decrease to 1800 mL.

### Investigate and inquire

- 1 Students need to research the solubility of each gas and what properties allow CO<sub>2</sub> to dissolve more readily than oxygen.
- 2
- a This is the students' graphs from the tabled results.
  - b The higher the temperature, the faster the molecules will move and therefore the greater space between the individual particles but the smaller possibility of different particles mixing together. Different temperatures have different effects on different gases.
  - c Tropical fish may have more blood flowing through their gills, allowing for more efficient oxygen uptake from the water.
- 3 Students may like to research a number of animals from a range of classification groups, e.g. examples of vertebrates and many invertebrates such as spiders, molluscs, insects.

Animal	Respiratory pigment	Pigment in cell or free in plasma	Type of pump
Human	Haemoglobin	In red blood cells	Heart – four-chambered
Spider	Haemocyanin	Free in haemolymph	Heart
Molluscs	Haemoglobin	Bound to blood cells	Heart – three-chambered

- 4 Students need to discuss the breakdown of food, by digestion, to the basic nutrients, which can then be used to build up tissues.

5

Lungs	Kidneys
Carbon dioxide (gas), water (liquid as vapour)	Urea (soluble solid), water (liquid)

Heat is not included under the solid, liquid or gas classification of wastes. It is lost mainly through the skin.

- 6 How a species will remove nitrogen from its body is determined largely by the amount of water usually available to it, and its complexity.
- 7 The tadpole and frog waste has been covered in the text. As mentioned earlier, it is beneficial when students are able to find out things that they do not know. A little research should show whether the crocodile egg produces a different waste from the adult.
- 8 The ammonia was coming from some of the bacteria in the soil, being produced as their nitrogenous waste compound.
- 9 The urea from the sweat is used by the bacteria on the skin, the waste product being ammonia. This can also occur in babies' nappies if they are left on too long.
- 10 'Kidneys only remove wastes' is not the full story as they control the amount and relative proportions of many substances, especially ions, in the blood, and hence affect the functioning of blood cells, nervous system and muscles and many organs such as the heart. Thus a person may have a heart attack, possibly fatal, if the ionic concentrations for the heart nerves and muscles are not appropriate. The kidneys also make substances necessary for the body: renin (which helps control the balance of ions and blood pressure), erythropoietin (important for the formation of haemoglobin and red blood cells) and the active form of vitamin D.
- 11 This is another question for the students capable of finding and understanding information by themselves. A tertiary physiology textbook is useful. Aldosterone increases the reabsorption of sodium in the collecting ducts. This hormone is in turn controlled by the renin-angiotensin system, which among other effects increases the amount of aldosterone produced as well as increasing sodium reabsorption. Much more is available from other reference sources.
- 12 More will be available with a little research on the student's part, but briefly the salmon cope in the sea, as many marine fish do, by excreting excess salt through the cells in their gills. In fresh water, their well-developed kidneys excrete large amounts of urine to remove the excess water that diffuses into their blood via their gills.
- 13 If a large quantity of water is drunk, the water as usual flows in the tubule of the loop of Henle; it re-enters the bloodstream by osmotically following the salts. Since there is no change in the amount of salts that are reabsorbed, the usual amount of water is reabsorbed with the salts, leaving the water not absorbed to continue to flow out of the kidney, producing a less dilute urine. Less ADH than normal would also be released from the pituitary gland in response to the lower salt concentration in the blood. Less ADH affecting the tubules means less water would be reabsorbed. If a large quantity of salt water is drunk (assuming it is not salty enough to cause the person to vomit) or the equivalent extra salt on food with normal water was drunk instead, then the following (simplified) would happen: some extra sodium is excreted, but some extra is also reabsorbed, taking with it extra water. So although the salt concentration of the blood remains the normal (more sodium, but more water), the person will carry extra fluid, mainly as extracellular fluid, and their body weight will increase, until the extra sodium is gradually released. (ADH, aldosterone, renin-angiotensin would also be involved.)